Exponents

Exponents

$2 \times 2 \times 2 = 2^3$

Power: 3

Base: 2

2 raised to the power 3.

Exponents → Repeated multiplications

$a^n = \underbrace{a \times a \times a \times \dots \times a}_{a \text{ is multiplied } n \text{ times.}}$

$n \Rightarrow$ whole no.

$125 = 5 \times 5 \times 5 = \boxed{5^3}$

5 cubed or 5 raise to the power 3.

$\boxed{125 = 5^3}$

$(-2) \times (-2) \times (-2) \times (-2) \times (-2) = (-2)^5$

$4 \times 4 \times (-2)$

$16 \times (-2) = -32$

odd no.

$(-2)^5 = -(2)^5$

$-(2 \times 2 \times 2 \times 2 \times 2)$

$-(32)$

$\boxed{-32}$

$(-2)^{4}$

$(-2) \times (-2) \times (-2) \times (-2)$

4 x 4

16

$-(2)^{4}$

$-[2 \times 2 \times 2 \times 2]$

-16

$$a^1 = a$$

$$7^1 = 7$$

$$5^1 = 5$$

$$x^1 = x$$

$$a^0 = 1$$

$$5^0 = 1$$

$$(-2)^0 = 1$$

$$x^0 = 1$$

$$\left(\frac{2}{3}\right) \times \left(\frac{2}{3}\right) \times \left(\frac{2}{3}\right) \times \left(\frac{2}{3}\right) = \left(\frac{2}{3}\right)^4$$

$$(-a)^{\text{odd no.}} = -(\text{number})$$

$$(-a)^{\text{even power}} = +(\text{number})$$

$1000 = (10)^3$

$100 = 10^2$

$a \times a \times a \times b \times b =$

Simplify $7^2 \times 2^2 = 49 \times 4 = 196$

$0 \times 10^2 = 0$

Simplify: $(-3) \times (-2)^3$

$\frac{(-3)^3}{4} \neq \left(\frac{-3}{4}\right)^3$

$(-1)^{7} = -1$

$(-1)^{10} = 1$

Simplify: $\left(\frac{-3}{4}\right)^3 = \left(-\frac{3}{4}\right) \times \left(\frac{-3}{4}\right) \times \left(\frac{-3}{4}\right)$

$= \frac{-27}{64}$ ✓

Simplify:

$$\left(\frac{1}{2}\right)^3 \times \left(\frac{-3}{5}\right)^3 \times \left(\frac{-4}{9}\right)^2$$

H.W.

$25 \Rightarrow 5^2$

5×5

$432 \Rightarrow \square^{\square}$ Prime factors

$128 \Rightarrow 2^3 \times 4^2 \Rightarrow 2^3 \times 2^4 \Rightarrow 2^7$ ✓

$4^2 = 4 \times 4$

$= 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$

$= 2^6$

$2^3 \times 4^2 = 8 \times 16$

$= 128$

12

$432 = 2 \times 2 \times 2 \times 2 \times 3 \times 3 \times 3$

$$432 = 2^4 \times 3^3$$

2	432
2	216
2	108
2	54
3	27
3	9
3	3
	1

Q. Express (i) 648 and (ii) 540 as a product of powers of their prime factors.

$$648 = 2^3 \times 3^4$$

$$540 = 2^2 \times 3^3 \times 5^1$$

$1000 = 10^3$

Powers of Prime factors.

1000

$\Rightarrow (10)^3 = (5 \times 2)^3 = 5^3 \times 2^3$

$16000 = 16 \times 1000$

$= 2^4 \times 2^3 \times 5^3$

$16000 = 2^7 \times 5^3$

$3600 = 3^2 \times 5^2 \times 2^4$

$= 2^4 \times 3^2 \times 5^2$

Express given rational nos. in exponential form.

(i) $\frac{27}{64} = \frac{3\times3\times3}{2\times2\times2\times2\times2\times2} = \frac{3^3}{2^6} = \frac{3^3}{4^3} = \left(\frac{3}{4}\right)^3$ ✓

$\frac{1}{2}$ ✓ $= 0.5$

(ii) $\frac{-27}{125} = \frac{(-3)\times(-3)\times(-3)}{5\times5\times5} = \frac{(-3)^3}{5^3} = \left(\frac{-3}{5}\right)^3$

(iii) $\frac{-1}{243} = \frac{-1}{3^5} = \frac{(-1)^5}{(3)^5} = \left(\frac{-1}{3}\right)^5$

$$\frac{-1}{3^4} = \frac{(-1)^4}{(3)^4} = \frac{-(1)^4}{(3)^4} = -\left(\frac{1}{3}\right)^4$$

Laws of exponents

(i) $a^n \times a^m = a^{n+m}$

(ii) $\frac{a^n}{a^m} = a^{n-m} \quad (n > m)$

$a^n \div a^m = a^{n-m} \quad (n > m)$

$2^3 \times 2^5 = 2^{3+5} = 2^8$

$\frac{3^7}{3^4} = 3^{(7-4)} = 3^3$

$\frac{3^7}{3^4} = \frac{3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3}{3 \times 3 \times 3 \times 3} = 3 \times 3 \times 3 = 3^3$

(iii) $a^0 = 1$

$$\frac{a^5}{a^5} = a^{5-5} = a^0 = \frac{a \times a \times a \times a \times a}{a \times a \times a \times a \times a} = 1$$

$$\frac{3^4}{3^4} = \frac{3 \times 3 \times 3 \times 3}{3 \times 3 \times 3 \times 3} = 1$$

$$\frac{3^4}{3^4} = 3^{4-4} = 3^0 = 1$$

$$5^0 = 1$$

$$\frac{5^{16}}{5^{16}} = 5^{16-16} = 5^0 = 1$$

(iv) $(a^m)^n = a^{m \times n}$

$((a^m)^n)^q = a^{m \times n \times q}$

Power of Powers

$\left(2^3\right)^4 = (2 \times 2 \times 2)^4 = 2^{3 \times 4} = 2^{12}$

$= \underline{2 \times 2 \times 2} \times \underline{2 \times 2 \times 2} \times \underline{2 \times 2 \times 2} \times \underline{2 \times 2 \times 2}$

$= 2^{12}$

$\left(\left(2^3\right)^4\right)^5 = 2^{3 \times 4 \times 5} = 2^{60}$

(v) multiply powers with the same exponents.

$$a^m \times b^m = (ab)^m$$

$a \neq 0$

$b \neq 0$

m is any natural no.

opposite → eg: $2^3 \times 5^3 = (2 \times 5)^3 = 10^3 = (1000)$

$(2^3 \times 2^4)$

(vi) $$a^{-n} = \frac{1}{a^n}$$

$$2^{-3} = \frac{1}{2^3}$$

$1000 \Rightarrow (10)^3 = (5 \times 2)^3 = 5^3 \times 2^3$

$$\frac{1}{2^1} = 2^{-1}$$

$$\frac{1}{2^3} = 2^{-3} = \frac{1}{2^3} = \frac{1}{8}$$

Q. $(-4)^3 \times (-2)^3 = ((-4)\times(-2))^3$

$= (8)^3$

Simplification using laws of exponents

(i) $2^5 \times 2^3 =$

$= 2^{5+3}$

$= 2^8$

(ii) $3^4 \times 3^2 \times 3^8$

$= 3^{4+2+8}$

$= 3^{14}$

(iii) $6^{15} \div 6^{10}$

$= 6^{15-10}$

$= 6^5$

(iv) $7^{3} \div 7^{14}$

$= 7^{3-14}$

$= 7^{-11}$

$= \frac{1}{7^{11}}$

(v) $\dfrac{\left(7^{2}\right)^{3}}{\div\ 7^{3}}$

$$\left(a^{m}\right)^{n} = a^{m \times n}$$

$= 7^{(2\times 3)} \div 7^{3}$

$= 7^{6} \div 7^{3}$

$= 7^{6-3}$

$= 7^{3}$

(vi) $2^5 \times 3^5 = (2 \times 3)^5 = 6^5$

(vii) $\left(2^{20} \div 2^{15}\right) \times 2^3$

$= \left(2^{20-15}\right) \times 2^3$

$= 2^5 \times 2^3$

$= 2^{(5+3)}$

$= 2^8$

Simplify and express the given expressions in exponential form.

(i) $\{(5^2)^3 \times 5^4\} \div 5^7$

$= \{5^{(2\times3)} \times 5^4\} \div 5^7$

$= \{5^6 \times 5^4\} \div 5^7$

$= \{5^{(6+4)}\} \div 5^7$

$= \{5^{10}\} \div 5^7$

$= 5^{10-7}$

$= 5^3$

$a^m \times b^m = (ab)^m$

$\frac{a^m}{b^m} = \left(\frac{a}{b}\right)^m$

(iii) $\dfrac{4^5 \times a^8 b^3}{4^5 \times a^5 b^2} = \left(\dfrac{4^5}{4^5}\right) \times \left(\dfrac{a^8}{a^5}\right) \times \left(\dfrac{b^3}{b^2}\right)$

$= 4^{5-5} \times a^{8-5} \times b^{3-2}$

$= 4^0 \times a^3 \times b^1$

$= 1 \times a^3 \times b$

$= a^3 \times b$

$= a^3 b$

OR

$\dfrac{\cancel{4}^{2} \times 2}{\cancel{2}} = 4$

OR

$\dfrac{8 \times 4}{4 \times 2} = \dfrac{8^2}{4} \times \dfrac{4^2}{2} = 4$

$= \dfrac{8}{2} \times \dfrac{4}{4} =$

(iii) $\dfrac{3^9 x^4 y^7 a^3}{x^3 a^2 3^7 y^5} =$

Simplify : $\left\{(2^2)^3 \times 3^6\right\} \times 5^6$

$= \left\{2^{(2\times3)} \times 3^6\right\} \times 5^6$

$= \left\{2^6 \times 3^6\right\} \times 5^6$

$= (6)^6 \times 5^6$

$= (6\times5)^6 = (30)^6$

Simplify: $\left(\frac{a}{b}\right)^5 \times b^{10}$

$= \frac{a^5}{b^5} \times \frac{b^{10}}{1}$

$= \frac{a^5}{1} \times \frac{b^{10}}{b^5}$

$= a^5 \times b^{(10-5)}$

$= a^5 \times b^5$

$= (ab)^5$

Simplify and write in exponential form.

(i) $25^4 \div 5^3$

$=$

(ii) $(8)^2 \div 2^3$

$= (2^3)^2 \div 2^3$

$= 2^{(3\times 2)} \div 2^3$

$= 2^6 \div 2^3$

$= 2^{(6-3)}$

$= 2^3$ ✓

$\frac{4 \quad 4 \quad 2}{8 \times 8}{2 \times 2 \times 2} = 8$ ✓

Simplify and write in exponential form.

H.W.

(i) $\dfrac{2^8 \times a^5}{4^3 \times a^3} = \left(\dfrac{2^8 \times a^5}{(2^2)^3 \times a^3}\right) = \dfrac{2^8}{2^6} \times \dfrac{a^5}{a^3} = {}^{8-6}2 \times {}^{5-3}a$

$= 2^2 \times a^2$

$= (2a)^2$

(ii) $\dfrac{2^3 \times 3^4 \times 4}{3 \times 32} = \dfrac{2^3 \times 3^4 \times 2^2}{3 \times 2^5}$

$= \dfrac{2^3 \times 2^2 \times 3^4}{2^5 \times 3}$

$= \dfrac{2^5 \times 3^4}{2^5 \times 3}$

$= \left(\dfrac{2^5}{2^5}\right) \times \dfrac{3^4}{3} = 1 \times 3^3$

$= 3^3$

$a^m \times a^n = a^{m+n}$

2	32
2	16
2	8
2	4
2	2
	1

$2^5 = 32$

Simplify :

① $\dfrac{(12)^4 \times (9)^3 \times 4}{6^3 \times 8^2 \times 27} = 162$

$= \dfrac{(2^2 \times 3)^4 \times (3^2)^3 \times 2^2}{(2\times 3)^3 \times (2^3)^2 \times 3^3}$

$= \dfrac{2^8 \times 3^4 \times 3^6 \times 2^2}{2^3 \times 3^3 \times 2^6 \times 3^3}$

$= \dfrac{2^8 \times 2^2 \times 3^4 \times 3^6}{2^3 \times 2^6 \times 3^3 \times 3^3}$

$= \left(\dfrac{2^{10} \times 3^{10}}{2^9 \times 3^6}\right)$

$= \left(\dfrac{2^{10}}{2^9}\right) \times \left(\dfrac{3^{10}}{3^6}\right)$

$= 2^1 \times 3^4$

$= 2 \times 3^4$

$= 2 \times 81$

$= 162$ ✓

9×9

$\left(2^2 \times 3\right)^4 = \left(2^2\right)^4 \times 3^4$

$\left(3^{(3)}\right)^{(3)} = 3^{3\times 3}$

$\dfrac{9^3}{6^3}$

$\left(\dfrac{3\cancel{9}}{\cancel{6}_2}\right)^3$

$\left(\dfrac{3}{2}\right)^3$

(11) $\dfrac{3^5 \times 10^5 \times 25}{5^7 \times 6^5}$

HW Simplify:

(1) $\dfrac{25 \times 5^{-2} \times t^8}{10^3 \times t^4} = \dfrac{5^4 \times t^8}{5^3 \times 2^3 \times t^4} = \left(\dfrac{5^4}{5^3}\right) \times \left(\dfrac{t^8}{t^4}\right) \times \left(\dfrac{1}{2^3}\right)$

$= \dfrac{5t^4}{8}$

(11) $2^{55} \times 2^{60} - 2^{97} \times 2^{18}$

$= 2^{115} - 2^{115}$

$= 0$

Simplify

(i) $$\frac{3^n + 3^{n+1}}{3^{n+1} - 3^n}$$

$$= \frac{3^n + 3^n \times 3^1}{3^n \times 3^1 - 3^n}$$

$$= \frac{3^n(1 + 3^1)}{3^n(3^1 - 1)} = \frac{3^n \times (4)}{3^n \times (2)}$$

$$= \left(\frac{3^n}{3^n}\right) \times \left(\frac{2^2}{2^1}\right)$$

$$= 2$$

$$\frac{2x + 2x5}{2(1+5)}$$

$$\frac{5 + 10}{10 + 5} = \frac{15}{5}$$

$$= 3$$

$$\frac{2x3 + 2x5}{2(3+5)}$$

$$\frac{10 \times 5}{10 \times 5} = \left(\frac{10}{10}\right) + \left(\frac{5}{5}\right)$$

$$3^n \times 3^1 = 3^{(n+1)}$$

$$3^{n+1} = 3^n \times 3^1$$

(iii) $2^3 \times a^3 \times 5a^4$

$= 2^3 \times a^7 \times 5$

$= 2^3 \times 5 \times a^7$ ✓

$= 40a^7$

$(5a)^4$ $\quad$ $5a^4$

Compare the following numbers.

(i) 2.7×10^{12} and 1.5×10^{8}

12 tens

$2.7 \times 10^{11} \times 10^{11}$

$1.5 \times 10 \times 10^{7}$

$27 \times 10^{11} > 15 \times 10^{7}$

$\sim 3 \times 10^{8}$ m/s

$10 \times 10 \times 10$

$3 \times 10000000 \ldots$

300,000,000 m/s

300,000 km/s

$2.7 \times 10 = 27$

$1.5 \times 10 = 15$

(i) 108×192

Product of prime factor in exponential form.

108

192

$= 2^2 \times 3^3 \times 2^6 \times 3$

$= 2^8 \times 3^4$

$2^3 = 2^{\boxed{3}}$

$2^5 = 2^n$

$\boxed{n = 5}$

$2^5 = 2^{(n+1)}$

$\boxed{n+1 = 5}$

$-1 \qquad -1$

$\boxed{n = 4}$

Find the value of n.

(i) $(2^2)^n = (2^3)^4$

$2^{2 \times n} = 2^{12}$

$2^{2n} = 2^{12}$

$2n = 12$

$n = \frac{12}{2}$

$n = 6$

(ii) $2^{5n} \div 2^n = 2^4$

$2^{4n} = 2^4$

$4n = 4$

$n = \frac{4}{4} = 1$

(iii) $2^{n-7} \times 5^{n-4} = 1250$

$2^{n-7} \times 5^{n-4} = 5^4 \times 2$

$\frac{2^n}{2^7} \times \frac{5^n}{5^4} = 5^4 \times 2$

H.W.

$2^{n-7} = 2^n \div 2^7$

$2^n \div 2^7 = 2^{n-7}$

① $5^{(n-2)} \times 3^{(2n-3)} = 135^{-}$

Value of n? —

$$\frac{5^n}{5^2} \times \frac{3^{2n}}{3^3} = 135^{-}$$

$$\frac{5^n}{5^2} \times \frac{3^{2n}}{3^3} = 5 \times 3^3$$

$$5^n \times 3^{2n} = 5^1 \times 3^3 \times 5^{-2} \times 3^3$$

$$a^m \div a^n = a^{m-n}$$

$$a^m \times a^n = a^{m+n}$$

$$5^n \times 3^{2n} = 5^{1+2} \times 3^{3+3}$$

$$5^n \times 3^{2n} = 5^3 \times 3^6$$

$n = 3$

(11) $2^{n-7} \times 5^{n-4} = 1250$

find the value of n.

$\frac{2^n}{2^7} \times \frac{5^n}{5^4} = 1250$

$= \frac{5^4 \times 2}{}$

$2^n \times 5^n = 5^{4+4} \times 2^{1+7}$

$2^n \times 5^n = 5^8 \times 2^8$

$2^n \times 5^n = 2^8 \times 5^8 \Rightarrow$

$n = 8$

$(5 \times 2)^n = (5 \times 2)^8$

$10^n = 10^8$

$n = 8$

$a^m \times b^m = (a \times b)^m$

$2^{n-7} \times 5^{n-4} = 1250$

Method 2

$2^{(n-7)} \times 5^{(n-4)} = 2^1 \times 5^4$

$\therefore \quad n-7 = 1$

$n = 8$

$n-4 = 4$

$n = 8$

To Check

$$5^{n-2} \times 3^{2n-3} = 135$$

Find m

$$(-3)^{(m+1)} \times (-3)^{(5)} = (-3)^{7}$$

method 1:

$$(-3)^{m+1} \times (-3)^{5} = (-3)^{2} \times (-3)^{5}$$

$$m+1 = 2$$

$$\boxed{m = 1}$$

method 2

$$\frac{(-3)^{m+1}}{(-3)^{5}} = (-3)^{7}$$

$$(-3)^{m+1} = (-3)^{7-5}$$

$$(-3)^{m+1} = (-3)^{2}$$

$$m+1 = 2$$

$$\boxed{m = 1}$$

method 3:

$$(-3)^{m+1+5} = (-3)^{7}$$

$$(-3)^{m+6} = (-3)^{7}$$

$$m+6 = 7$$

$$\boxed{m = 1}$$

Q. If $25^{n-1} + 100 = 5^{2n-1}$, find the value of n.

$(5^2)^n = 5^{2n}$

$25^{n-1} + 100 = 5^{2n-1}$

$100 = 5^{2n-1} - 25^{n-1}$

or, $5^{2n-1} - 25^{n-1} = 100$

$\frac{5^{2n}}{5^1} - \frac{25^n}{25^1} = 100$

$\frac{5^1 \times 5^{2n}}{5 \times 5} - \frac{5^{2n}}{25} = 100$

$\frac{5^{2n+1}}{25} - \frac{5^{2n}}{25} = 100$

$\frac{5^{2n} \times 5}{25} - \frac{5^{2n} \times 1}{25} = 100$

$5^{2n}(5-1) = 100 \times 25$

$5^{2n} \times 4 = 5^2 \times 4 \times 5^2$

$5^{2n} = 5^4$

$2n = 4$

$n = 2$

$\frac{1}{5} \times 5 - \frac{2}{25}$

$x = 2$

$2 = x$

$x + 20 = 2x$

$x - 2x = -20$

$-x = -20$

$x = 20$

$x + 20 = 2x$

$20 = 2x - x$

$20 = x$

$x = 20$

(i) $\left(\frac{2}{3}\right)^{3} \times \left(\frac{2}{3}\right)^{5} = \left(\frac{2}{3}\right)^{n-2}$

find n.

(ii) If $\frac{p}{q} = \left(\frac{2}{3}\right)^{2} \div \left(\frac{6}{7}\right)^{0}$, find the value of $\left(\frac{p}{q}\right)^{3}$.

Sol:

$$\frac{p}{q} = \left(\frac{2}{3}\right)^{2} \div 1$$

$$\frac{p}{q} = \left(\frac{2}{3}\right)^{2}$$

$$\therefore \left(\frac{p}{q}\right)^{3} = \left(\left(\frac{2}{3}\right)^{2}\right)^{3}$$

$$= \left(\frac{2}{3}\right)^{2\times 3} = \left(\frac{2}{3}\right)^{6}$$

$$\left(\frac{125}{8}\right)^5 \times \left(\frac{125}{8}\right)^n = \left(\frac{5}{2}\right)^{18}$$

find n.

$$\frac{5^3}{2^3} = \left(\frac{5}{2}\right)^3$$

1 → 2 3 4 5 6 → 7 → 8 → 9 10 → 11 12 13 14 15 20

Squares and Cubes.

$2^2 = 4$

$\boxed{2^3 = 8}$

$3^2 = 9$

$3^3 = 27$

$4^2 = 16$

$4^3 = 64$

$5^2 = 25$

$5^3 = 125$

$5^4 = 625$

Exponents are used to express huge number

mass of earth $5,976,000,000,000,000,000,000,000.0\ kg$

25

25.0

↓

expressed in standard form using exponents.

Decimal no. 1 to 9 $\times$ 10^{n}

$5.976 \times 10^{24}\ kg$ standard form.

$59.76 \times 10^{23}\ kg$ ✗ not a standard form.

Express the given no. in Standard form.

(i) $3,907,625 = 3.907625 \times 10^{6}$

3907625.0

1000000

10

(ii) $3,186,500,000 = 3.1865 \times 10^{9}$

Usual form — Standard form

$3.1865 \times 10^{9} = 3186500000$

Standard form to Usual form.

$9.325 \times 10^{12} = 9325000000000$

Speed of light = ~~$3 \times$~~ 2.99×10^{8} m/s. 3×10^{8} m/s

↓ Usual form

299,000,000 m/s

Simplify

(i) $\left(3^5\right)^{11} \times \left(3^{15}\right)^{4} - \left(3^5\right)^{18} \times \left(3^5\right)^{5}$

(ii) $$\frac{10 \times 5^{n+1} + 25 \times 5^{n}}{3 \times 5^{n+2} + 10 \times 5^{n+1}}$$

$$= \frac{2 \times 5^{1} \times 5^{n+1} + 5^{2} \times 5^{n}}{3 \times 5^{n+2} + 2 \times 5^{1} \times 5^{n+1}}$$

$$= \frac{2 \times 5^{n+2} + 1 \times 5^{n+2}}{3 \times 5^{n+2} + 2 \times 5^{n+2}}$$

$$= \frac{5^{(n+2)}(2+1)}{5^{(n+2)}(3+2)}$$

$$= \frac{3}{5}$$

H.W

Q. If $\dfrac{(9)^n \times 3^2 \times 3^n - (27)^n}{(3^3)^5 \times 2^3} = \dfrac{1}{27}$, find the value of n.

$$\frac{(3^2)^n \times 3^2 \times 3^n - (3^3)^n}{3^{15} \times 2^3} = \frac{1}{27}$$

$$\frac{3^{2n} \times 3^{(2+n)} - 3^{3n}}{3^{15} \times 2^3} = \frac{1}{27}$$

$$\frac{3^{(2n+2+n)} - 3^{3n}}{3^{15} \times 2^3} = \frac{1}{27}$$

$$\frac{3^{(3n+2)} - 3^{3n}}{3^{15} \times 2^3} = \frac{1}{27}$$

$$\Rightarrow \frac{3^{3n} \times 3^2 - 3^{3n} \times 1}{3^{15} \times 2^3} = \frac{1}{27}$$

$$\Rightarrow \frac{3^{3n}(3^2 - 1)}{3^{15} \times 2^3} = \frac{1}{27}$$

$$\Rightarrow \frac{3^{3n} \times 8}{3^{15} \times 8} = \frac{1}{27}$$

$$3^{(3n+2)} = 3^{3n} \times 3^2$$

$$2x - 1x$$

$$x(2 - 1)$$

$$= x$$

$$\frac{3^{3n}}{3^{15}} = \frac{1}{27}$$

$$\frac{a^{x}}{a^{y}} = a^{(x-y)}$$

$$3^{(3n-15)} = \frac{1}{3^{3}} \quad \times$$

$$\frac{1}{27} = \frac{1}{3^{3}} = 3^{-3}$$

$$3^{3n-15} = 3^{-3}$$

$$\frac{1}{a^{n}} = a^{-n}$$

$$\Rightarrow \quad 3n - 15 = -3$$

$$3n = 12$$

$$n = \frac{12}{3}$$

$$n = 4$$

$$\frac{1}{27} = \frac{1}{3^3} = \frac{3^0}{3^3} = 3^{0-3} = 3^{-3}$$

$$\frac{1}{a^x} = a^{-x}$$ Reciprocal rule.

$$1 = 3^0$$

$$\frac{1}{a^x} = \frac{a^0}{a^x} = a^{0-x} = a^{-x}$$

$$a^x = \frac{1}{a^{-x}} \qquad \frac{1}{2^{-3}} = 2^3$$

(i) $a^m \times a^n = a^{m+n}$

(ii) $\frac{a^m}{a^n} = a^{m-n}$

(iii) $(a^m)^n = a^{mn} = (a^n)^m$

(iv) $a^n \times b^n = (ab)^n$

$(ab)^n = a^n \times b^n$

(v) $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$

~~(vi)~~ $0^2 = 0$

$0^3 = 0$

$\left(\frac{2}{3}\right)^5 = \frac{2^5}{3^5}$

(vi) $a^0 = 1$

(vii) $a^1 = a$

(viii) $\boxed{a^n = \frac{1}{a^{-n}}}$ or $\boxed{\frac{1}{a^n} = a^{-n}}$

(ix) $\boxed{0^0 = 1}$

$312,456,000.0 = 3.12456 \times 10^{8}$

$0.000,000,009\,1 = 9.1 \times 10^{-9}$

9.1×10^{-31} kg.

$0.00023 = 2.3 \times 10^{-4}$

$$\left(\frac{3}{2}\right)^4 \times \left(\frac{3}{2}\right)^5 = \left(\frac{3}{2}\right)^{2n+1}, \quad \text{find } n.$$

H.W

$$\left(\frac{3}{2}\right)^9 = \left(\frac{3}{2}\right)^{2n+1}$$

$$2n+1 = 9$$

$$2n = 9-1$$

$$2n = 8$$

$$n = \frac{8}{2} = 4$$

① $0.3x + 0.4 = 0.28x + 1.16$, Solve for x.

$0.3x - 0.28x = 1.16 - 0.4$

$0.02x = 0.76$

$x = \frac{0.76}{0.02} = \frac{76}{2} = 38.$

$$\frac{9^8 \times (x^2)^5}{(27)^4 \times (x^3)^2}$$

Simplify and write it in exponential form.

$$\frac{(3^2)^8 \times x^{10}}{(3^3)^4 \times x^6}$$

$$\frac{3^{16} \times x^{10-6}}{3^{12}} = 3^4 x^4 = (3x)^4$$

Simplify :

(i) $(3^5)^{11} \times (3^{15})^4 - (3^5)^{18} \times (3^5)^5$

(ii) $$\frac{(16)^7 \times (25)^5 \times (81)^3}{(15)^7 \times (24)^5 \times (80)^3} = \frac{(2^4)^7 \times (5^2)^5 \times (3^4)^3}{3^7 \times 5^7 \times (2^3 \times 3)^5 \times (2^4 \times 5)^3}$$

$$= \frac{2^{28} \times 5^{10} \times 3^{12}}{2^{27} \times 5^{10} \times 3^{12}}$$

$\div 16$

$$= \frac{2^{28} \times 5^{10} \times 3^{12}}{3^7 \times 3^5 \times 5^7 \times 5^3 \times 2^{15} \times 2^{12}}$$

$= 2^1 \times 1 \times 1 = 2$

End of the chapter